

# PATENT SPECIFICATION (11)

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(21) Application No. 49925/75 (22) Filed 5 Dec. 1975 (19)  
(31) Convention Application Nos. 534 817 (32) Filed 20 Dec. 1974  
564 412 2 April 1975 in

(33) United States of America (US)  
(44) Complete Specification published 8 Nov. 1978

(51) INT. CL.<sup>3</sup> G09F 13/16 19/22

(52) Index at acceptance

G5C 18U 7  
B2E 18Y 19Y 207 209 20Y 23Y 319 339 359 36X 429  
44Y 456 457 459 466 539 639 658 669 749  
E1G 41 44C1 64A3 64B2 64B3 64C2 64CX



## (54) RETROREFLECTIVE ELEMENTS

(71) I, ROBERT BRUCE BAGSHAW, a citizen of the United States of America, of 2024 North Oak Lane, State College, Centre County, Pennsylvania 16801, United States of America, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention is concerned with improvements in or relating to retroreflective elements and coatings including the elements, the elements and coatings being suitable for application to road surfaces, signposts and the like.

In the prior art, it has become commonplace to utilise retroreflective elements and markers of various types, on streets and highways to provide night time identification of centre lines, edge lines, medians, obstacles, obstructions and signs. In fact, it has become commonplace for retroreflective material to be used in large quantities for traffic control, especially on signs.

Retroreflective material is a material that requires no power of its own, but reflects light back to or towards its source. It has become especially important as a safety aid on highways and functions in a manner such that light from an automobile headlight striking a retroreflective material is reflected back towards the driver's eyes, creating the appearance of illumination of the retroreflective material.

Examples of prior art developments utilizing retroreflective characteristics for signs, traffic control devices and other purposes are disclosed in United States Patent Specifications Nos. 1,902,440; 2,251,386; and 2,294,930. In these specifications there is disclosed the use of minute glass spheres, with the attendant inherent retroreflective capabilities of glass spheres. Originally, traffic signs were produced by applying a coating of paint or binder to the surface and then applying a uniform layer of glass

spheres to the coating while wet, permitting the spheres to become partially imbedded in the coating with approximately 50% of the sphere surfaces left exposed. These spheres are ordinarily half silvered, placed on a silvered surface, or partially covered with a metallic paint, in order to provide the desired reflective qualities. Signs made according to the techniques of prior developments, such as described in the three above-mentioned patent specifications were effective except under adverse weather conditions. When the signs become set, due to rain falling on the sign surfaces, the lenticular surface of the sign, comprising a plurality of glass beads, was distorted, thereby reducing the ability of the spheres to act as retroreflectors.

The solution to that problem, while taking the form of various methods, basically involved the use of a flat overlay on the spherical surfaces, to prevent destruction of the spherical shapes that provided the overall surface. Examples of various methods that are used to prevent the destruction of the lenticular surfaces of the beads that include the use of flat overlays are disclosed in United States Patent Specifications Nos. 2,326,634; 2,543,800; 2,592,882; and 2,713,286. The flat overlays or sheet materials disclosed therein are in each instance retroreflective materials in the form of planar sheets, each having a plurality of minute retroreflective components preferably in the form of glass beads.

In that phase of highway safety that is addressed to delineating streets and highways by painted lines, it has become accepted as a method, and commonplace throughout the world, that glass beads are applied to the highway by applying a paint or binder to the highway surface and then dropping or embedding minute glass spheres into the wet paint or binder. An example of this technique is disclosed in U.S. Patent Specification No. 2,267,995. The retroreflective capability

of the glass beads so imbedded works rather well during dry weather but is totally non-effective during wet weather, as in rain, due to the destruction (from a lenticular standpoint) of the retroreflective surfaces of the beads by the presence of rain water thereon. A further disadvantage inherent in this technique for delineating streets and highways resides in, for all practical purposes, a limitation of the colour of the light returned to the source, to either white or yellow, the colours normally applied to the highway surface by the paint or binder.

Retroreflective materials of the type employing a flat overlay, as discussed above with respect to United States Patent Specifications Nos. 2,326,634; 2,543,800, 2,592,882; and 2,713,286, while working well in the vertical plane as applied to stop signs and the like, would not work well when applied to a horizontal surface such as a roadway, and in fact would be completely non-effective due to a basic and well-known optical principle.

The optical principle involved is that the angle of incidence of light approaching a retroreflective surface cannot exceed 40° or 45° if it is desired to have any light reflection back to the light source. By angle of incidence is meant the angular measurement of the path of light toward the surface, as measured from a perpendicular to the surface. Automotive headlamps of course direct light onto road surfaces at incident angles that are effectively generally greater than 80°, and that often approach 90° incident angles, whereby the light beam is parallel to the horizontal surface.

It has been known in the art to use various elevated markers having retroreflective qualities, and with some success. The most common of such markers are molded-plastics units that extend sufficiently high above the highway surface to prevent water from destroying the lenticular surfaces of the beads employed, and hence from destroying their retroreflective qualities. Such markers are generally expensive, time consuming upon installation, and are subject to accidental removal by snowploughs. Examples of such constructions are present in United States Patent Specification Nos. 3,043,196; 3,171,827; 3,175,935; 3,254,563; 3,255,282 and 3,418,869.

While all of these constructions present improvements under dry weather conditions, none are really effective under adverse conditions, specifically, under wet weather conditions, because of lenticular destruction of surfaces of beads, cylinders and aggregates when wet.

The present invention provides a three-dimensional retroreflective element, for use as a safety aid for road markings, signposts and the like, when used in quantity in ran-

dom arrangement on a surface of use, the element being of a size such that it projects from the surface of use by an amount within the range of 0.005 inch to 0.025 inch, the element including at least one substantially planar surface portion the shape of the element being such that when positioned for use, the at least one substantially planar surface portion is upstanding from said surface of use; the at least one upstanding substantially planar portion being provided by an external layer of a material having a refractive index substantially equal to that of waver, the external layer providing a protective covering for a plurality of retroreflective components.

There now follows a detailed description which is to be read with reference to the accompanying drawings of elements, coatings and methods of making them according to the invention; it is to be understood that these embodiments have been selected for description to illustrate the invention by way of example.

In the accompanying drawings:—

Figure 1 is a perspective view of a roadway employing reflective coatings in the form of delineation lines, stripes in the horizontal plane, and of a sign employing indicia in the vertical plane, with the indicia and stripes, lines et cetera, being constructed in accordance with the present invention;

Figure 2 is a side elevation illustrating angles of incidence from light of a given source, on different horizontally disposed and vertically disposed surfaces, of the type contained in the illustration of Figure 1;

Figure 3 is an enlarged transverse sectional view, taken through a stripe illustrated in Figure 1, generally along the line III—III of Figure 1, and wherein retroreflective elements according to the invention disposed or embedded in a paint or binder as applied to a road surface, are illustrated, under wet or rainy conditions;

Figure 3A is a view similar to that of Figure 3, but wherein alternative retroreflective elements according to the invention are illustrated;

Figure 3B is a view also similar to that of Figure 3, but wherein a combination of other alternative retroreflective elements according to the invention is illustrated;

Figure 4 is an enlarged sectional view taken through one of the elements illustrated in Figure 3, generally along the line IV—IV of Figure 3;

Figure 5 is an enlarged fragmentary cross-sectional view, taken through a suitable retroreflective sheet material for use with the present invention;

Figure 6 is a view similar to that of Figure 5, but wherein an alternative retroreflective sheet material is illustrated, also suitable for use with the present invention;

Figure 7 is a schematic view, in perspective, of one technique for manufacturing retroreflective elements in accordance with one embodiment of the present invention;

Figure 8 is an enlarged perspective view of one of the elements manufactured by the technique of Figure 7;

Figure 9 is a perspective view of an element somewhat similar to that of Figure 8, but having a modified longitudinal configuration;

Figure 10 is a schematic view, in perspective, of a manufacturing technique for making another form of retroreflective element in accordance with the present invention;

Figure 11 is an enlarged perspective view of one of the elements made in accordance with the technique of Figure 10;

Figures 12, 13, and 14 are each perspective views of different modified forms of retroreflective elements in accordance with the present invention, each employing a different geometric shape, but each embodying retroreflective sheet material on the surface thereof, and a core of hardenable material;

Figure 15 is a schematic perspective view of another manufacturing technique for making retroreflective elements in accordance with the present invention;

Figure 16 is an enlarged perspective view of a retroreflective element made in accordance with the technique of Figure 15;

Figure 16A is an enlarged fragmentary detailed view of a portion of the illustration of Figure 16, wherein the components of the retroreflective element embedded in a transparent plastic binder are more clearly illustrated;

Figure 17 is a schematic perspective illustration of one technique for applying retroreflective elements made in accordance with the present invention, to a paint or binder disposed along a surface, for example, such as a highway surface;

Referring now to the drawings in detail, reference is first made to Figure 1, wherein a roadway surface 20 is illustrated having a divider line marker 21 against oncoming traffic, along with lane markers 22, 23, and 24.

A signpost 25 is disposed alongside the road with a sign 26 containing indicia 27 thereon.

The markers 21 to 24 are each provided by a coating having retroreflective qualities, in accordance with the present invention. Similarly, the indicia 27 is likewise formed.

It will be understood that the markers 21 to 24, and in fact the indicia 27 may be of the paint-on type, whereby a paint, binder or the like is applied to the surface 20 or to the sign 26, as appropriate, with retroreflective elements then being dispersed onto the thus painted surface, or, in the alternative, the coating may be in the form of a

non-fluid, solid laminate having retroreflective elements projecting therefrom. As a further alternative, the coating could be applied in the form of a paint with retroreflective elements already dispersed through the paint prior to its application to the surfaces desired, although such would not be preferable.

Referring to Figure 2, it will be seen that a light source 28 is shown, representing a headlight of, for example, an automobile shining down onto the roadway surface 20, and depending upon the speed of the vehicle, the angular orientation of the head lamp (i.e., whether high beams or low beams are on), the curvature of the road, etc., it will be seen that light may strike the highway markers 23 and 24, as indicated. For example, light from the source 28 may be incident on the lane marker 23 in the direction of the arrows 30, at an angle of incidence "a" (angle with the perpendicular 31 to the surface 20). Upon striking retroreflective elements 32 in the coating providing the marker 23, light is returned towards its source, as indicated by the arrows 34.

The light from the source 28 is also illustrated as being directed toward and reflected from retroreflective elements 35 of the marker 24, such light approaching the elements 35 of the marker 24, such light approaching the elements 35 in the direction of the arrows 36 at an angle of incidence "b", and returning from the elements 35, as indicated by the arrows 37.

It will be noted that each of angles "a" and "b" are substantially in excess of 45°, and realistically, in excess of 80°.

It will also be noted that light from the source 28 is illustrated in Figure 2 as proceeding towards the retroreflective surfaces of the indicia 27 of the sign 26, in the direction of the arrow 38, and returning therefrom in the direction of the arrows 40, at an angle of incidence "c", of approximately 15° to the road surface.

The binder for the markers 22, 23, 24 and even the binder for the indicia 27 on the sign 26 may comprise a paint, resin or the like, preferably of originally liquid composition, that is hardenable to comprise a solid. The binders for the markers 22, 23, 24 are generally applied to the road surface 20 when wet. Various compositions for the binders may be utilized, including but not limited to any of the binders disclosed in the several U.S. patents mentioned herein, for example, the pigmented binder film disclosed in U.S. Patent 2,267,995, embodying an organic silicate vehicle, or any other desired type of binder. It will generally be preferable that the binder be pigmented, and in instances in which highway stripes are to be utilized, preferably white or yellow pigments are desirable. However, red pigments

or other warning-related colorings may be utilized as desired.

Referring to Figure 3, a transverse cross-sectional view taken through the marker 21 of Figure 1 is illustrated; the marker comprises a plurality of randomly oriented elements 41, projecting upwardly from the coating of binder coated on the road surface 20. Each of the elements 41 is of multiple surface construction, partially embedded within the coating 21, and preferably having a maximum dimension within the range of from 0.015 inches to 0.090 inches, but the sizes of the elements or shapes can vary from 0.005 inches to 0.250 inches; or even up to any size that is practical to form or fabricate from existing retroreflective materials. The numerical sizes indicated immediately above are preferably for highway or pavement markings, but larger sizes can be utilized if desired as a substitute for expensive raised plastics units. Additionally, elements 41 in larger sizes may be employed either as components of the indicia 27, or separately for use on vertical surfaces such as median barriers and abutments.

The numerical size ranges indicated herein are applicable to the various styles or types of retroreflective elements embraced within this invention, irrespective of any particular manner of manufacture.

A film 42 of rain is illustrated coating the elements 41 in Figure 3.

In Figure 3A, a solidified liquid-applied binder 43 is illustrated applied to a road surface, with an alternative form of element 44 embedded therein, and in Figure 3B, another coating 45 of binder is illustrated on a road surface 46, with four different alternative-shape element 47, 48, 50 and 51 embedded therein, such shapes respectively being cylindrical, spherical, triangular or prism-like, and rectangular. Additionally, other shapes such as conical, frusto-conical, and irregular may also be utilized.

One of the elements 41 is illustrated in Figure 4 as comprising a pair of originally planar sheet-like portions of retroreflective material of any desired commercial type, 52 and 43, secured together with any suitable adhesive 54 therebetween, and which have been bent into a "V" shape as illustrated in Figure 4, to have an acute included angle between internal surfaces 55 and 56, and a complementary angle between outer surfaces 57 and 58. Each of the originally flat sheets 53 and 52 may be constructed by any of the techniques disclosed herein for making flat retroreflective sheets of material, as indicated in the several U.S. cited patents herein, but preferred constructions of the sheet material may be one of the disclosed in any U.S. Patent Specifications Nos. 2,326,634; 2,713,286; 2,592,882; and 2,543,800. Most if not all of these disclo-

tures involve the use of glass spheres, although alternatively the spheres could be of plastics or other material. A typical construction for the sheet material is illustrated in Figure 5 as comprising an optional base layer 60 of paper, plastics or the like, which has a layer 62 of metal (for example aluminum) foil disposed thereon, with dimples or recesses therein, for accommodating glass beads 63, each of minute (microns) size. The glass spheres 63 will have a refractive index within the range of 2.0 to 2.9 and more specifically within the range of 2.2 to 2.6, with the index 2.9 being optimum. A transparent, but optionally colored paint, plastics or the like provides a layer 64 disposed over and about the layer of spheres 63, the layer 64 having a refractive index approximating that of water, or of about 1.4, or within the range of about 1.338 (generally a fluoroplastic) to about 1.70 (a phenol-formaldehyde or phenol-furfural), but preferably within the narrower range of about 1.4 to about 1.65. By the use of coloring in the transparent layer 64, the light returned to a source retroreflected off of a surface of the type 65, can have any desired coloring, such as red for danger or yellow for caution. Also, the surface 65 will generally be flat for efficient light refraction into the spheres. Water 66 from inclement weather or otherwise will generally have a refractive index of about or substantially the same as that of the substance 64.

With reference to Figure 6, another alternative construction for the sheet layers 52 and 53 is illustrated, such construction being the one that provides the several exterior surfaces of the elements 44 of Figure 3A. In Figure 6, a backing 70 of paper, plastics or the like is illustrated, with a foil layer 71, similar to that 62 of Figure 5, and with glass spheres 72 also being provided in dimples of the foil layer, but wherein the spheres 72 are each constructed to have a refractive index of about 1.90 to about 1.92, (optimum range) and with a plurality of paper, plastics or the like spacers 74, as illustrated in Figure 3A, having an overall weblike arrangement, serving to space the outer transparent layer 75 from the foil 71, with only air 76 disposed therebetween around the spheres 72. The transparent layer 75 may, like the layer 64 of Figure 5, be tinted or colored, and may be provided by any suitable laminate, paint, plastics or the like, that will have the desired refractive index, again approximately to that of water, within the range of about 1.338 to about 1.70, and preferably within the range of about 1.40 to about 1.65. The advantage of construction such as that of Figure 6 for the sheet material that is used to make the elements 41 and 44, is that the glass beads 72 do not have to be the same high quality

that will yield the high refractive index required by the beads 63 of Figure 5, in the construction of Figure 6. Also, in Figure 6 a water layer 77 is illustrated, as in Figure 5.

The sheet materials 52 and 53, and those that have constructions similar to those illustrated in Figures 5 and 6, or suitable constructions, are available commercially, such as the SCOTCHLITE and "FLAT-TOP" brands of reflective sheeting (all grades) and are designated by those trademarks, and manufactured by 3M Company of St. Paul, Minnesota. Other companies manufacturing suitable sheet materials for use in making elements in accordance with the present invention may include the Morgan Adhesives Company of Stow, Ohio, that provide a reflective sheeting designated by the trademark MACLITE (7200 Series). Similar materials are manufactured by other companies, many of which would be usable in accordance with would be products of Fasson Products Company, and new corner cube material produced by Rowland Development Company under the trademark name "REFLEXITE". Many of these products come in various colors, and the color of the returned light can be predetermined by selection of the proper color of sheeting.

Many of the retroreflective materials are referred to in the literature as being "reflex-reflective". It will be understood that these terms are used synonymously herein.

With reference to Figures 3A and 3B in particular, it will be noted that the elements of the present invention, 47, 50, 51, 44 and 41 may be used separately, or together with other element shapes of the present invention, and either separately, or in conjunction with glass beads 48. The reason for this is that, as applied to a highway marker, for example, the glass beads 48 function in a highly efficient manner during conditions of dry weather. By mixing conventional glass beads with elements in accordance with the present invention, an economic saving can be effected, in that, the elements constructed in accordance with the present invention have such high retro-reflectivity, that the degree of saturation that would normally be used of glass beads is not required for elements in accordance with the present invention. Accordingly, a percentage of the solids that are dispersed onto the surface of a binder 45 may comprise elements in accordance with the present invention and another percentage of those solids may comprise glass beads or spheres 48, that, when taken together, will provide the desired retro-reflectivity under both wet and dry weather conditions.

One method of manufacturing elements in accordance with the present invention is illustrated in Figure 7. This method uses

commercially available sheet retroreflective material provided in the form of rolls or ribbons 81, 82, 83 of the material, and comprises delivering them in the direction of the arrow 84, to pass through the junction 85 formed by forming wheels or rollers 86, to make a long ribbon 87 of layers of the commercially available sheet retroreflective material, having three continuous legs thereof, each with two surfaces of retro-reflective material, angularly related to each other, and then serially and sequentially severing the elongate material 87 thus formed by passing the same through a severing knife 88 and knife block 90, to yield a plurality of elements 91, formed one after the other, each identical.

With particular reference to Figure 8, an element 91 is illustrated in greater detail as comprising three legs 92, 93 and 94, each having its two opposite surfaces comprised of originally planar sheet retroreflective material, of an above-discussed commercially available type.

With reference to Figure 9, another example is given of a configuration that may be desired, having some similarities to that illustrated in Figure 8, with three legs 95, 96 and 97, but being constructed from flat circles of sheet retroreflective material. Generally, elements made in accordance with Figure 9 will not be mass-produced in accordance with the process of Figure 7, and will be somewhat larger, for application to poles, bridge abutments, bicycle spokes, with the sizes being selected depending upon the desired application.

With particular reference now to Figure 10, an alternative version of the manufacturing technique of the present invention is disclosed, wherein the three dimensional elements 100, illustrated in somewhat larger form in Figure 11, in the form of sheet retroreflective material 101 on the surface of a triangular core 102. This is made by first providing a roll 103 of a ribbon of sheet retroreflective material of a commercially available type with one or both (preferably both) surfaces having retroreflective qualities, running the same through a series of rollers or the like 104 that comprise a forming die that forms the ribbon 105 into a triangular or trough-like configuration 106. A thermosetting resin or like hardenable or settable material 107 is applied to the trough 106 by an appropriate dispensing nozzle 108, and the whole process being practiced continuously, the trough with the resin therein is then delivered past or beneath a heater 110 that serves to set or harden the resin, followed by delivery of the then hard or almost hard composite 100 to a shearing mechanism 111, comprising a blade 112 and a suitable support fixture 113. The result is a solid retroreflective element 100 having

surfaces of retroreflective sheet material. If the material is comprised of two sheets back-to-back of retroreflective material, and if the resin 107 is transparent, the element 100 is more efficient.

Referring to the embodiments of Figures 11 to 14, the core, if desired may be of any suitable material, other than those specifically disclosed herein above. For example, extruded polyvinyl chloride, polycarbonates, or cellulose acetate butyrate are typical plastics that can be utilized. The olefin group of plastics, including polyethylene, is not generally suitable due to problems with adhesion of the same to the retroreflective sheet material, although the same may be suitable upon overcoming the adhesion problems.

Typical resins that may be usable in the embodiments of Figures 10 to 14, may include polyesters such as Reichhold Chemicals', trademark brand "POLYLITE", of polyester resins, and epoxies such as the epoxy designated by the trademark "BAKELITE" of Union Carbide. Suitable specific resins, preferably of thermosetting types may be selected from these examples, and from others commercially available.

Generally, the configuration of Figure 12, indicated by the number 114, resides in providing sheet retroreflective material, in circular form, by spiral configuration or otherwise, and then filling the hollow cylindrical configuration thus formed with a hardenable resin or other suitable material followed by cutting off the composite thus formed to size by a shear. An alternative method of manufacture thereof would be to extrude a core of resin material, and then wrap the core thus extruded with a tape of sheet retroreflective material. Similarly, the rectangular configuration of Figure 13, and the triangular configuration of Figure 14 may likewise be constructed, either by first preparing the casing of retroreflective material and filling it with a hardenable substance, or by first extruding a rod of hardenable substance having the desired cross-sectional configuration, and then wrapping or otherwise covering it with a covering of sheet retroreflective material. The core material could also be wood, metal, etc or any other hard or hardenable substance, and may be of any desired shape; e.g. triangular or semi-circular in transverse cross-section, with retroreflective material wrapped, adhered or otherwise applied to surfaces thereof. Moreover, the core could be of a rigid, but non-filling construction, e.g. metal angle with retroreflective material on a surface or surfaces thereof.

With particular reference to Figure 15, another alternative manufacturing technique is provided in the form of an extruding apparatus 120, into which resin and beads

are delivered continuously, with the extruder 120 being suitably motor driven or otherwise, to provide a continuous rod 121 of a circular or other desired cross-section, that comprises a mixture of the resin and beads dispersed or embedded therein, at least near the surface portions of the rod 121, and with the composite rod 121 thus formed then being delivered past the knife 122 of a shear 123 for cutting of the same to length, to yield retroreflective elements 124. The element 124 is illustrated in somewhat greater detail in Figure 16, as comprising a plurality of glass beads 125 embedded in a resin 126. The beads 125 each have half-silvered surfaces, such silvering or metalizing if desired, having been pre-provided by conventional techniques. The beads 125 will be randomly oriented such that light passing through the transparent colored or non-colored plastics or other suitable binder 126 will likely strike some of the beads at the desired angular orientation to penetrate the beads, be reflected at the silvered or otherwise metalized surface and returned toward the source of light. It will be understood that colored light returned can be achieved by introducing transparent pigments into the resin or other suitable binder 126. It will also be understood that the exterior surfaces of the element 124 will be smooth, for purposes of light penetration.

In the embodiment of Figures 15 to 16A, the glass beads will each have a refractive index of at least about 2.0 and up to about 2.9 and the binder 126 will have a refractive index within the range of about 1.338 to about 1.70, and preferably within the range of about 1.40 to about 1.65.

With reference to the embodiment of Figures 15, 16 and 16A, the binder 126 may comprise a thermoplastic resin, such as that provided by General Electric Company under the trademark "LEXAN" brand of polycarbonate.

An alternative process for producing the elements 124 is by casting. A mixture of a clear polyester casting resin and half-silvered glass spheres each preferably having a refractive index in the range of about 2.2 to about 2.6, poured into a metal mold having a V-shaped groove in its surface, upon curing, will yield small triangular strips, with glass spheres embedded therein, that can be sheared to length. The elements 124 will generally be suitably pigmented as for example as described in U.S. Patent Specification 2,543,800, or any other commercial resin or other type of binder commercially available, either with the pigmentation already supplied therein by the supplier, or added thereto for desired coloring, at the place of manufacture of the elements, as is desired. The cast or extruded elements may take on any of various shapes and may even be hol-



low; e.g., hollow cylindrical configurations, hollow rectangular configurations, with the minute retroreflective components near, but embedded in exterior surfaces thereof. Also, the minute retroreflective components, in lieu of comprising half-silvered beads could comprise small chips or particles of sheet retroreflective material, if desired, with either one or both sides thereof having retroreflective qualities.

With particular reference to Figure 17, a suggested manner of application of the elements for highway or pavement markings is illustrated, wherein means 130 is provided for delivering paint, as from a spray gun or the like onto a surface 131 of a road, such spray gun 130 being mounted on the back of a truck or the like, to yield a ribbon of paint 132, with a second truck or a downstream portion of the same truck or other vehicle including a dispenser 133 of elements in accordance with the present invention, dispensing the elements from the dispensing container 133 onto the wet paint or other suitable binder 132, from a conventional sphere dispenser. It will be noted that the elements dispensed from the dispensing container 133 may be either all elements in accordance with the present invention, or a mixture of those elements with spheres or other suitable elements, as desired, and as has been discussed herein above. The thickness of the binder or paint 132 will be controlled in order to provide proper adhesion of the binder to the roadway surface 131, and most especially to provide proper embedment of the elements 134 being dispensed from the dispenser 133, into the binder 132. As an alternative, a separate dispensing device similar to that of 133 may be used to dispense glass spheres into the binder 132 separately from the dispensing of elements in accordance with the present invention into the binder 132. The binder, besides comprising paint, may be any similar type of binder disclosed herein for the intended purposes, including thermoplastic binders or the like, depending upon the desired durability of the marker.

The retroreflective elements may be constructed from retroreflective sheeting having one side that is retroreflective, that are bent into the shapes illustrated for sheeting herein, and that may take on other configurations. For example, the sheeting may be spirally wound if desired, be wound to hollow cylindrical shapes, if desired, or may be laminates of different layers of sheeting, as desired. In instances in which the sheeting will be of a type having two retroreflective faces, the configurations may be of those types illustrated herein (for example see Figures 8, 9, 11,) for example, as well as Figure 4, and the several embodiments illustrated in Figure 3B, and furthermore, L-shaped sections may

be utilized, or almost any other shape desired.

Where solid or substantially solid constructions are to be made, that do not have sheet portions of retroreflective material on the surface thereof like those of Figures 11 to 14, but are constructed more along the lines of the constructions of Figures 16 and 16A, it will be apparent that, here again, any of various forms may be used. In such instances, the components may comprise spheres disposed adjacent a metallic surface for retroreflective components, then the metallic surfaces and the spheres covered with a coating similar to the substance 126 in Figure 16A. In the alternative, the spheres may be of the half-silvered type. In other instances, a metallic foil core could have a plurality of beads disposed thereabout, then all of which are embedded in a substance such as that 126 in Figure 16A. In this embodiment, the metallic core would take the place of the silvering on the spheres 125 of Figure 16A. Thus retroreflective elements, it will be seen, may taken on many configurations. However, each of the configurations will have a surface coating (that may or may not be the same substance in which the elements are embedded), that is of substantially the same refractive index as that of water, and with some means inside for reflecting light back toward its source. In many instances that means may comprise beads that are half-silvered to reflect light or the beads may be disposed on some embedded metallic surface, as desired. A further alternative is to construct retroreflective elements by embedding in a substance such as that 126 of Figure 16A, or some suitable other resin, minute flecks of sheet retroreflective material, dispersed at random in the resin, and all of which, when taken together, comprise a retroreflective element in accordance with the present invention. One manner of providing such flecks would be to provide either single or double face sheet retroreflective material, and to quickly freeze it, as by application of liquid carbon dioxide, and while such sheet material is frozen to run it between a pair of fracturing rollers, that will fracture the sheet material into separate particles. These particles may then be dispersed in larger beads (up to about  $\frac{1}{4}$  inch, if desired), randomly, or even arranged, if desired in resin drops, or other desired three-dimensional shapes such as cylinders and tetrahedrons.

Also, various irregular shapes may comprise cores, that are provided with silvered-spheres adhered to the surface thereof, and that then have a smooth coating of a resin of any of the types mentioned herein as would be suitable for the substance 126 of Figure 16A, for example.

In instances in which minute half-silvered beads or tiny flecks of planar sheet retro-reflective material are embedded in small droplets of resin that have the same refractive index as about that of water, the droplets comprised thereby may, if desired, be sprayed out of a spray gun and solidified in various forms, as desired. Still another alternative would be to utilize sheets of retro-reflective material of the type described herein for example with reference to Figures 5 and 6, such sheets either being back-to-back, or not, and to then extrude an overlay of a substance such as that 126 in Figure 16A thereover, in any of many various shapes for subsequent severing of the extrudate-on-sheets thus formed into discrete elements.

#### WHAT WE CLAIM IS:—

1. A three-dimensional retroreflective element, for use as a safety aid for road markings, signposts and the like, when used in quantity in random arrangement on a surface of use, the element being of a size such that it projects from the surface of use by an amount within the range of 0.005 inch to 0.250 inch, the element including at least one substantially planar surface portion, the shape of the element being such that when positioned for use, the at least one substantially planar surface portion is upstanding from said surface of use; the at least one upstanding planar surface portion being provided by an external layer of a material having a refractive index substantially equal to that of water, the external layer providing a protective covering for a plurality of retroreflective components.

2. An element according to Claim 1, wherein said refractive index of the external layer is within the range of 1.338 to 1.70, wherein each retroreflective component has a refractive index which is within the range of 2.0 to 2.95 and wherein a reflective medium is provided adjacent portions of said components.

3. An element according to either one of Claims 1 and 2 wherein said external layer has a refractive index within the range of 1.4 to 1.65.

4. An element according to any one of Claims 1 to 3 wherein said components each have a refractive index within the range of 2.2 to 2.6.

5. An element according to any one of the preceding claims and of multiple surface substantially solid core construction, wherein said retroreflective components and said external layer together comprise a retro-reflective sheet material secured to the core on at least said upstanding surface portion of the element.

6. An element according to any one of the preceding claims, wherein said retro-reflective components comprise glass beads

partially coated with a reflective medium and embedded in a substantially solid substantially light transparent substance of multiple surface construction that provides said external layer.

7. An element according to any one of the preceding claims wherein the refractive index of the glass beads is in the range of 1.80 to 1.95 and wherein a reflective medium is provided adjacent portions of said components.

8. An element according to Claim 5, wherein said components comprise a layer of spheres of refractive index within the range of 2.4 to 2.95, said external layer comprising a coating in which said minute spheres are partially embedded sandwiched between a reflective medium and said external layer.

9. An element according to Claim 7, wherein said components are provided by a layer of spheres.

10. An element according to Claim 1, wherein said components are glass spheres of refractive index within the range of 1.9 to 2.95, the glass spheres having a coating of a medium on portions thereof.

11. An element according to Claim 5, wherein said retroreflective sheet material comprises at least two portions that are bent in relation to each other at least one of which portions provides a said upstanding surface portion.

12. A retroreflective element according to Claim 1, wherein the three dimensional shape thereof is provided by three generally planar leg portions, each of double-faced retroreflective construction, with a common junction, and with said leg portions being angularly disposed relative to each other.

13. An element according to Claim 12, wherein said three legs are angularly orientated approximately 120° apart.

14. An element according to Claim 13 wherein each said leg is generally rectangular in side elevation.

15. An element according to Claim 13 wherein each said leg is generally semi-circular in side elevation.

16. An element according to Claim 2 wherein said components and reflective medium comprise flecks of planar sheet retroreflective material embedded in said external layer.

17. An element according to Claim 2 wherein said components are disposed in said external layer.

18. A reflective coating for use as a safety aid for substantially horizontal, e.g. road, surfaces and the like for use in providing visible light reflection back toward the light source even when the angle of incidence of light relative to the surface of use exceeds 45°, the coating comprising a plurality of retroreflective elements in ac-



- cordance with any one of the preceding claims, said elements being dispersed in random arrangement relative to each other in a carrier, each said element being of a size such as to project out of the carrier in up-standing attitude from the surface to be coated by an amount within the range of 0.005 inch to 0.250 inch when the coating is applied to the surface.
- 10 19. A coating according to Claim 18, wherein said carrier is a solid of originally liquid composition, selected from resin and paint.
- 15 20. A coating according to either one of Claim 18 and 19, wherein at least some of said elements are oriented and dispersed in said carrier for impingement thereon of

light at an angle of incidence relative to the surface of use that is greater than 80°.

21. An element according to claim 1 substantially as hereinbefore described with reference to any one of Figures 1 to 6, 8, 9, 11 to 14, 16 and 16A of the accompanying drawings.

22. A method of making an element, as set forth in Claim 1, substantially as hereinbefore described with reference to Figure 7, Figure 10, Figure 15 or Figure 17 of the accompanying drawings.

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Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon), Ltd.—1978  
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY  
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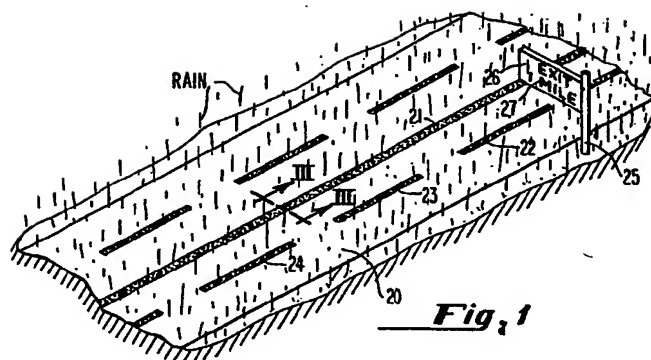
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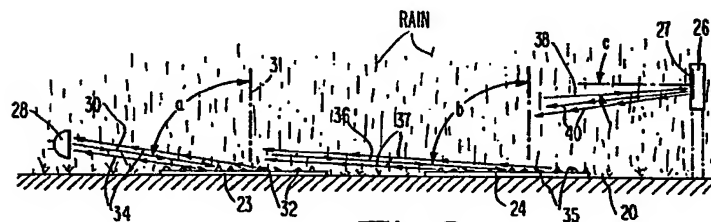
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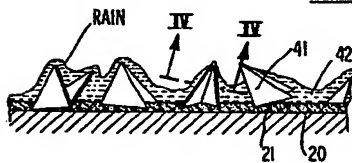
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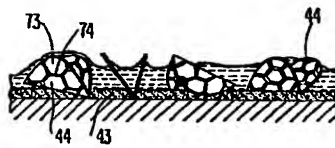
**Fig. 1**



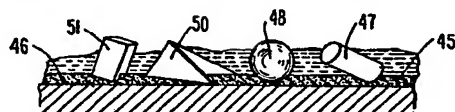
**Fig. 2**



**Fig. 3**



**Fig. 3A**



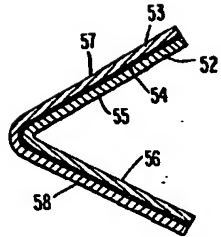
**Fig. 3B**

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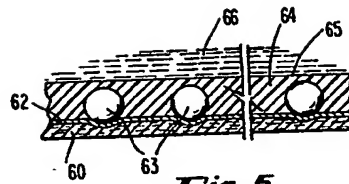
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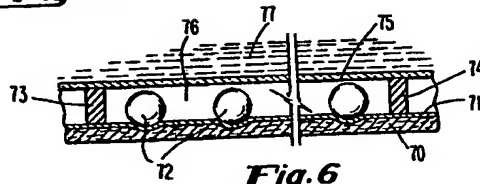
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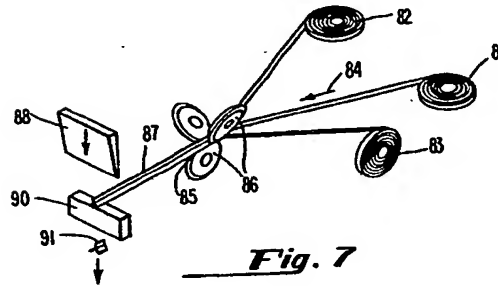
**Fig. 4**



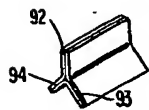
**Fig. 5**



**Fig. 6**



**Fig. 7**



**Fig. 8**



**Fig. 9**

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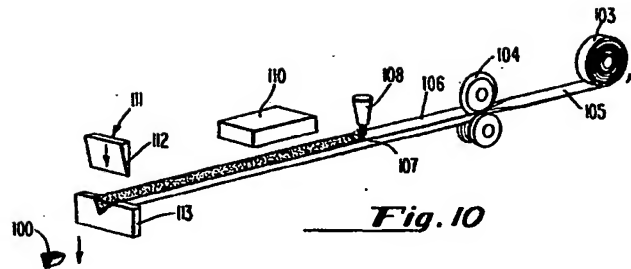


Fig. 10

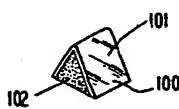


Fig. 11



Fig. 12



Fig. 13



Fig. 14

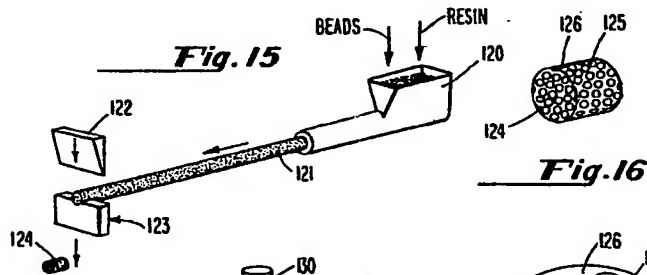


Fig. 15

Fig. 16

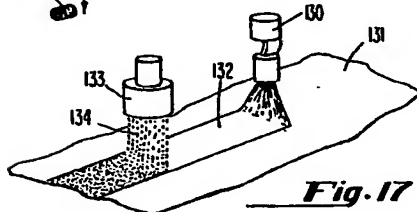


Fig. 17

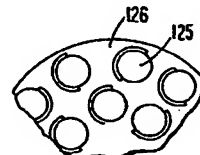


Fig. 16A

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